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AUTHOR Bates, A. W.
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ABSTRACT

This paper argues that there will be greater use of independent learning and distance education in the future combined with increased use of technology due to the demand for continuing adult education and new methods of teaching. Research into new technology in education will become a priority as the use of technology will require large-scale investments. Research should be aimed at identifying appropriate teaching roles for different technologies; how media differ from one another in the way they present, represent, and organize knowledge; and how this relates to cognitive learning processes. Research will also be required in the methodology of cost-analysis to enable institutions to identify the nature of costs in using technologies and to compare differences between media within the same system. Major changes will be required in the organization of teaching and administration, and research is needed to resolve questions about the best way to organize teaching when using the new technologies. Essentially, there will be a need for new approaches to research and for adequate, independent funding. (DJR)

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Research into the Use of Advanced Technology in Education: Future Requirements

- DR.A.W.BATES -

Reader in Media Research Methods

Institute of Educational Technology

Open University

Walton Hall

Milton Keynes

England

IR012304

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FUTURE DEVELOPMENTS IN EDUCATION

While the first part of the conference will deal in detail with likely future developments in education, there are two developments on which there is likely to be little disagreement.

New priorities for education

Firstly, there will be changes in the priorities given to different target groups for education.

Currently, in developed countries, state funding for education has been directed primarily at children and young people in full-time education. For most people, formal education has traditionally ceased somewhere between the age of 16 and 21, and has taken place within fixed buildings known as schools, colleges or universities.

However, this model of education is being challenged by the rapid development of new technologies. Information technology in particular requires changes to current educational provision for a number of reasons.

People at work using or affected by information technology have continually to up-grade their knowledge and skills, as the technology develops. It is no longer adequate (if it ever was) for professionals such as doctors, engineers or civil servants suddenly to cease education after leaving university. New technology has similar implications for skilled workers: new technology is replacing many traditional skills, or fundamentally changing the nature of the

work of craftsmen and artisans. It is now recognised that to keep in employment, workers may need to change their work - not just in terms of employers, but also skills - several times in their life-time.

Furthermore, the traditional education system finds it extremely difficult to respond quickly enough to the changing needs of industry and commerce. There is a long delay betweeen investment in school education and economic benefits later (although the benefits may be long lasting); investment in adult education and training can bring immediate results.

Another consequence of new technological developments is increased leisure activities, either forced or unforced. It is a matter of some dispute as to whether new technology will inevitably lead to greater unemployment, but certainly over the next 20 years, it seems highly likely that many more people will have a great deal of leisure time, whether the cause is unemployment, early retirement, shared work, shorter working weeks or just more old people. Education is likely to be seen as one useful and profitable way of spending this leisure time. It is worth noting that the demand for this kind of adult education is likely to come from the more educated and articulate of the voting population; at the same time, society is likely to see continuing education (in a broad sense) as one way to avoid alienation amongst the young unemployed.

The <u>demand</u> then for continuing adult education is almost certain to grow; however, this must be seen against an economic and political climate in many countries where governments are trying to <u>reduce</u> the level of expenditure on state education.

There are really four main options open to any government wishing to expand continuing education:

to expand continuing education using conventional teaching methods (i.e., adult education classes) through a major increase in State funding;

to reduce formal education provision in order to release funds for continuing education;

to encourage industry and market forces to develop continuing education through the private sector (e.g., commercial correspondence schools, company training);

to seek new ways of providing continuing education which permit more provision at no greater cost.

While the first three are to a large extent political options, the fourth is more of a technological solution. Governments of a number of countries in Europe, North and Latin America and Asia have put their faith in this last option to expand continuing education.

New methods of teaching

Although there are doubts regarding how quickly it will happen, the second major development is likely to be in methods of teaching.

Partly this will be a result of the increased demand for continuing education.

For many people, it is just not practical nor convenient to spend fixed times, particularly during working hours, in conventional classes. Adults need to keep working to support their families, and employers are reluctant to release highly skilled personnel for long periods of training away from work. A large part of continuing education then will be on a part-time basis, and there will be a preference for education and training which is home or work-based.

Teaching methods will also have to be changed because of the shortage of people with the new skills in information technology and related areas. These people can earn much more working in industry and business than they could get from teaching, and in any case often lack the necessary teaching skills.

The new technologies also encourage the development of independent and distance learning. Learners can study from text, video and computers, either in their own home or at their place of work, at times that are convenient to them or their employers, without the need for extensive face-to-face tuition.

Lastly, there is a belief in some political quarters that new technology is more cost-effective than conventional face-to-face teaching. It will be seen that there is little hard evidence for this assumption; nevertheless, there is growing concern at the apparent ineffectiveness and inefficiency of conventional teaching methods. Governments, employers and parents are demanding better results from education for the money spent. One argument is that for improvements to occur, new methods of teaching must be tried; it is hoped that the use of new technology will provide one possible way to improve teaching effectiveness.

Whether the reasons are good or bad, it is clear that there will be considerable pressure to use new technology in education. Furthermore, this will require large-scale investment, possibly at the expense, in the long-term, of face-to-face provision. This in itself is likely to cause a great deal of controversy, with parents, students and teachers.

It seems to be essential therefore to find out when and how technology **should** be used in education, the likely **effects** of new technology on learning and social development, and the likely **cost-benefits**, if any, of introducing such technologies.

RESEARCH GOALS

In setting research goals, it is important to learn from mistakes in the past. The most common research paradigm in this field is the comparative, laboratory-controlled study, comparing learning gains achieved from one medium with learning gains achieved through another. In this model, in order to control variables, the learners (usually undergraduate volunteers) in each group are as closely matched as possible, and the teaching is kept exactly the same in each group, or as near as possible, except for the two media used.

There is not space here to provide a detailed criticism of this approach (see Bates, 1981a for a full critique of this method). It is sufficient to point out that this research approach has proved to be completely useless in making practical decisions about the use of different teaching media.

Also, there is a danger in concentrating research into one technology. For

instance, there are proponents of interactive video-discs or the use of artificial intelligence in computer-based learning who will argue that if enough money is put into research in their area, they will be able to produce the "definitive" teaching medium. However, experience suggests that there is no "super-medium" which can meet all the differing needs of education, at least at reasonable cost. Generally, a careful, limited range of media is required in most teaching situations.

What is needed then is a better understanding of what roles different media can play in education. Secondly, a better understanding is needed of what factors to take into consideration when deciding on media use. While teaching roles are important, in a real-world situation they are not the only factor: costs, teacher and student convenience, organisational requirements, and availability of suitable equipment and "courseware" are also important. These factors have for too long been neglected in research studies.

It would be inappropriate in a short paper to try and define all the areas of research required, but given the rationale in the paper so far, I would suggest that the following areas, which to date have received scant attention from researchers and funding agencies, are particularly important if different technologies are to be used properly in education:

Identification of appropriate **TEACHING ROLES** for different technologies

This research would be aimed at identifying the unique teaching features of each medium (text, television, computers, face-to-face, etc.). All media are substitutable: in other words, given enough time, money and inspiration,

anything can be taught through any medium. However, research to date suggests that it is easier to do some things through one medium rather than another. This research needs to be more precise in identifying what these unique roles are for each medium, and will require developments in a number of different but related directions.

Research for instance is required into how different media differentially **represent or present** knowledge in different subject areas. Pioneering work in this area has already been carried out in France by Jacquinot (1978) on educational television. A number of different theoretical approaches could be adopted, including semiological and semantic analysis; it does seem though that technologies differ particularly in the way that they **structure** knowledge (compare, for instance, broadcast television with videotext or computers).

One implication of this is that some media might more easily suit some subject areas, or at least some approaches to teaching, than others. For instance, subject areas differ considerably in the way they organise and structure knowledge (compare literary criticism for instance with mathematics).

Another area of research into the different teaching roles of media, conducted at the British Open University (Bates, 1984a; Jones, 1984) is concerned with identifying what direct **learning experiences** and **teacher functions** can be adequately substituted for distance learners through media, e.g. field visits through television, diagnosis and remediation of learning difficulties through computer-assisted learning.

Research is also needed to identify how different media help develop or inhibit

the development of different **cognitive learning skills.** Several researchers (e.g. Salomon, 1979; Olson and Bruner, 1974) have argued that **content** (e.g. facts, ideas, relationships) can be taught independently of media presentation, but **skills** (e.g. analysis, application, evaluation) are media dependent. While an interesting proposition, there is very little empirical evidence to support this hypothesis. If it is true, it is still necessary to identify which skills are best developed through which medium.

Promising research has begun on the **isomorphism** between media presentation and the cognitive processes used to develop comprehension. Salomon (1979) has identified three isomorphic characteristics of television (illustration, modelling and supplantation); there is a need to identify not only other characteristics of different media which are isomorphic, but also characteristics which help learners to **transform**, integrate or develop their knowledge.

Whatever the direction of the research, attempts to identify how media differ from one another in the way they most conveniently present, represent and organise knowledge, and how this relates to cognitive learning processes are most likely to enable educators to identify when and how media should be used. This approach would appear to offer more pragmatic results than crude, blanket comparisons between the learning outcomes of the same content taught in the same way across two different media, which has tended to be the primary research approach up to now in North America, or enthusiastic "case-studies" of individual media use, prevalent in Europe.

Identification of COSTS

Very naive assumptions have been made by educational planners about the likely cost benefits of introducing new technology to education. There is little evidence to suggest that the introduction of new technology actually reduces teaching costs; experience to date suggests that in most cases, where the technology is appropriate and well used, it will lead to increased **benefits**, but actual expenditure usually increases also. Thus **unit costs** (i.e. the average cost per student covered by the system) may be reduced, a higher **quality** of student may be achieved, **more** students may be taught, or **new** students (e.g. working adults) may be recruited, but irrespective of the benefits, overall costs are likely to be greater as a result of using technology.

There have been numerous studies on the economics of educational media (e.g. Jamison, Klees and Wells, 1976; UNESCO, 1977; Wagner, 1982). There is certainly a need to look at the costs of whole **systems** of teaching, rather than individual experiments or demonstration projects involving the use of new technology, which do not necessarily reflect the real costs of running an operational system.

Two leading experts in the economics of educational media are French, Eicher (1977) and Orivel (1980). However, most economic analyses of media-based teaching systems have been carried out on projects for **developing** countries, partly because the sponsoring agencies (The World Bank, United Nations Development Programme) are concerned with returns on dollar investment, be it in education or agriculture.

More careful financial monitoring is needed of on-going systems of teaching heavily dependent on technology use in **European** countries (such as the Open

Universities in Britain, West Germany and Holland, or micro-computer development programmes for schools in Britain, France, and West Germany), to ascertain where expenditure is incurred, and the extent to which these costs are directly or indirectly dependent on the use of technology. Such studies would be extremely valuable for educational planners at central or local government level in France, because the economic and cultural conditions would be more similar than studies carried out in developing countries.

However, these more macro-economic analyses, dealing with costs of whole systems, have their limitations. A good deal of work still needs to be done on the **methodology** of such cost analyses. Some of the assumptions commonly made in cost-analyses of whole systems so far have been both hypothetical and questionable (e.g. calculation of "opportunity" costs, i.e. the rate of return if the money had been invested in industry instead).

Furthermore, these macro-economic approaches to cost analysis are not much help to internal decision-making **within** most institutions, such as schools, universities or distance learning systems. Within an institution, it is necessary to make decisions about use of media within relatively fixed budgets. (It does not help a Dean of Academic Affairs for instance to know he would do better to invest his teaching budget on the stock market, rather than on a new computer!).

Also, what **matters** or counts as a cost can vary considerably from institution to institution. For instance, broadcasting may be available without being a direct cost on one educational institution's budget, while for another it may be a crippling cost. Main-frame computer purchase (as for universities in the U.K.)

may come from an external source separate from the normal university teaching budget; this may encourage purchase and use of computing equipment even though the costs of teaching through a main-frame system are higher compared with those that would be incurred by using other media that have to be paid for out of the normal teaching budget (such as micro-computers).

What is needed therefore is a **method of cost-analysis** which enables an institution to identify the **nature** of costs in using technology, appropriate to that institution's decision-making needs. For instance, which costs are **variable** (i.e can be altered according to level of output or use of a technology, such as the costs of copying and distributing video-cassettes) and which are **fixed** (i.e. must be paid no matter what the level of use, e.g. mainframe computer purchase or rental and maintenance)? Once a coherent and practical system of assessing internal costs has been developed, this can then be applied to analysing differences between media within the same system, or to enabling more relevant comparisons to be made with more traditional methods of teaching.

What is clear is that the introduction of technology does radically change the cost **structure** of teaching. In general, technology-based education systems incur high start-up costs, and require large numbers of students using the same materials to justify the high level of initial expenditure, but their marginal costs (i.e the cost of adding extra students to the system) tend to be lower.

Economists tend to argue that cost analysis is less of a problem in education than measuring the benefits. It is certainly true that there is little value in looking at costs alone, unless a purely monetarist approach of reducing expenditure irrespective of loss of benefits is accepted. Also, measuring the

output of an educational system can be notoriously difficult, especially if output is defined strictly in monetary terms (i.e. the value of a graduate).

However, the research aim does not always have to be to justify the overall level of educational expenditure. It may be just as valuable to compare either the relative costs in achieving the same educational objectives by using different technologies within fixed budgets, or what new objectives could be obtained by using new technologies, and at what cost. In such studies, measurement of benefits may be less of a problem than in evaluating the overall benefits of an education system. It is essential though always to look at costs in relation to benefits, taking into consideration that new technology may bring benefits not possible in other ways.

Analysis of **ORGANISATIONAL** issues in using new technology effectively

One important lesson emerging from successful applications of technology to education is that major changes are required in the organisation of teaching and administration. There are indeed a great many questions to be resolved about the best way to organise teaching when using the new technologies.

For instance, what is the best way to produce integrated, multi-media teaching materials? It is clear that the production of such materials requires the input of a number of specialists, such as subject experts, media designers (e.g. television producers, computer programmers, text editors, graphics artists) and instructional designers. Or are instructional designers a redundant luxury? Should specialists be employed within an institution, or contracted in as and when necessary? How should the design and production process be organised to

ensure good communication and understanding between the various people involved in producing such materials?

Once materials are produced, how should the teaching be organised? Is the system of teaching in regular-size groups with a teacher always present still necessary, when using new media? Indeed, do learners have to attend classes regularly, if the materials can be delivered and studied at home? What is the role, if any, of face-to-face tuition in a multi-media teaching context?

Another range of questions centres around the administration of teaching institutions using new technology. For instance, to what extent can - or should - the same media be used for administrative as well as teaching purposes? For instance, can student registration and records, staff payments, financial control be carried out on the same computer system as teaching activities, such as computer-assisted learning? If so, who decides priorities, and how?

Another major question is whether the introduction of new technology should lead to changes in the way budgets are allocated and administered. For instance, should there be a reduction in staffing budgets to allow for increased media production? If so, how can such decisions be taken in educational institutions like universities where academic staff, through their Senate, have the ultimate decision-making power?

This last question raises the fundamental point of how systems heavily dependent on new technology should be managed. Experience suggests that teachers as individuals are not necessarily resistant to change, but the management of educational institutions tends to be in the hands of those who stand to lose

most from the introduction of new technology - those controlling major budgets which may have to be trimmed to allow for increased expenditure on technology, heads of departments that may have to share power or lose it to new areas, such as media production, and the most senior staff who have less incentive to change their teaching methods.

Institutions or projects where technology has been successfully introduced and used need to be monitored, so the lessons of how this was managed and organised can be learned. This requires a very different kind of research from the traditional measurement of learning gains or analysis of costs, a point discussed in more detail in the next section. In particular, though, when funding is being considered for major innovations in the use of technology, as much attention needs to be paid to questions of organisation as to costs and curriculum development.

MINIMUM RESEARCH REQUIREMENTS

The poverty of traditional research methodology

One has to start by acknowledging the limitations of traditional educational research methodologies practiced in many universities, with regard to research into new technologies. I am arguing for research which is more action-oriented and more closely linked to decision-making. In general, this requires the careful monitoring and accurate description of new developments, based on a close appreciation of the complex context in which such developments tend to take place.

This monitoring should cover not only the learning outcomes, but the process of curriculum development, an analysis of the roles ascribed to media, and the system of organisation with respect to allocation of resources and the design, production and delivery of media-based materials. This requires a method of research best described as "illuminative evaluation" (e.g. see Parlett and Hamilton, 1972) rather than the comparative, laboratory-controlled research method so popular in many North American universities. However, I have also suggested that research based on identifying differences between media in different teaching roles will advance our knowledge further than just descriptive case-studies of various projects using media.

The need for theory

One of the major problems facing researchers in this field is the lack of adequate theories of instruction. If the different teaching roles of different media are to be identified, this should be within the context of a general theory of instruction, which attempts to describe and explain the process of instruction, the role of media within that process, and the relationship of instruction to learning.

There are a number of existing general theories of instruction, (e.g. Bloom et al., 1956; Bruner, 1966; Skinner, 1968; Gagne, 1977), and a number of approaches which attempt to relate procedures for media selection to these theories (e.g. Romiszowski, 1974; Anderson, 1976; Reiser and Gagne, 1982). The common factor though in all these theoretical models is that the decision-making process is based on very fine, detailed decisions regarding very small, finite

instructional events. In other words, the teaching or learning process is fragmented into basic elements of activity.

There are obvious problems with this approach. First, it assumes in the initial process that teachers have a full range of media to choose from. However, media choice usually operates across at least two quite distinct levels.

An institution is likely to take **strategic** decisions about what range of media will be made available to teachers. Thus a school may decide to buy a video-recorder or a micro-computer, not because of a need to teach a specific subject in a particular way, but because it is believed that the equipment will have general value within the school, for many children. Similarly, a distance education institution may decide to install a mainframe computer primarily for administrative reasons, but then find that it can also be usefully employed for teaching purposes.

Teachers then find themselves in a position where certain media are available, while others are not. It is only at this **tactical** level that teachers can start taking more precise decisions about which of the available media to use. Unfortunately, though, the theoretical models pay little attention to the equally if not more important strategic levels of decision-making.

Second, there is an implicit assumption in theoretical models of a direct relationship between objectives, instructional tasks, and choice of media. However, these models very rarely spell out, even less prove, what these relationships are. It is difficult for most of these theories to accommodate the findings of recent research conducted by Salomon (1979) and researchers at

the British Open University (Bates, 1984a), who have attempted to provide empirical evidence for the unique roles of individual media within the instructional process.

These models of media selection based on systems theory have also tended to concentrate mainly on pedagogic issues. Mention is usually made of the need to consider practical factors, such as costs and equipment availability, but most models suggest that this should be done only after a review of learning-related factors, usually as a means of deciding between two or more media already chosen as appropriate on pedagogic grounds. Then little help is given about how to identify and weight practical factors. (For an account of the very wide range of factors that have to be taken into consideration when selecting and using media, see Bates. 1981b).

It is clear that if new technologies are to be used effectively, it will be necessary to develop a more powerful theory of instruction which will give direction to research in this area, and which takes into account not only the role of different media in the instructional process, but also other factors important in the decision-making process, such as costs, availability, and organisational requirements.

Centres of research

Another feature of research into the educational applications of new technologies is the low priority given to this area of study by most conventional universities. One reason for this is that industrial applications of new technology are more likely to attract research grants to people who

understand the potential of new technologies; another reason is the priority given by conventional subject departments to research proposals in their own field at the expense of new fields such as new technology in education; thirdly, government research funding bodies often lack the necessary expertise to assess adequately research proposals in this area.

As a consequence, research into the application of new technology to education has tended to be fragmented and unco-ordinated. What is needed is a co-ordinated programme of research linked to on-going developments and projects where new technology is being systematically applied to education, but independent of the actual department carrying out the innovation. This would require setting up two or three centres for research of this kind over an extended period of several years, to allow for continuity and a build-up of research expertise.

Adequate, independent research funding

This in turn will require adequate, independent research funding. At a time when most governments are trying to reduce public expenditure, this will not be a popular proposal. However, it is necessary to consider the likely investment costs in new technology. For instance, the provision of about one hour per week "terminal time" per pupil for access to a micro-computer would seem a very modest long-term goal for primary school pupils. Nevertheless, this would still mean a six-fold increasein current provision in Britain, which already is one of the best equipped countries in Europe regarding micro-computer provision in schools. Across the EEC as a whole it will need a further investment of 10,000 million ECUs at current prices. At this level of investment, a relatively small

investment in research activity to identify the most appropriate roles for different media, and the conditions necessary for their successful implementation, would seem more than justified.

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ABSTRACT

It is argued that there will be greater use of independent learning and distance education in the future, combined with increased use of technology. Research into new technology in education should therefore be a high priority. Three kinds of research are required: an identification of the different teaching roles for each medium; development of methods of cost-analysis which help to make decisions about which media to use; and research into the organisational changes needed to ensure that technology is used successfully in education. The paper ends with a brief discussion of the need for new approaches to research and for adequate, independent funding.